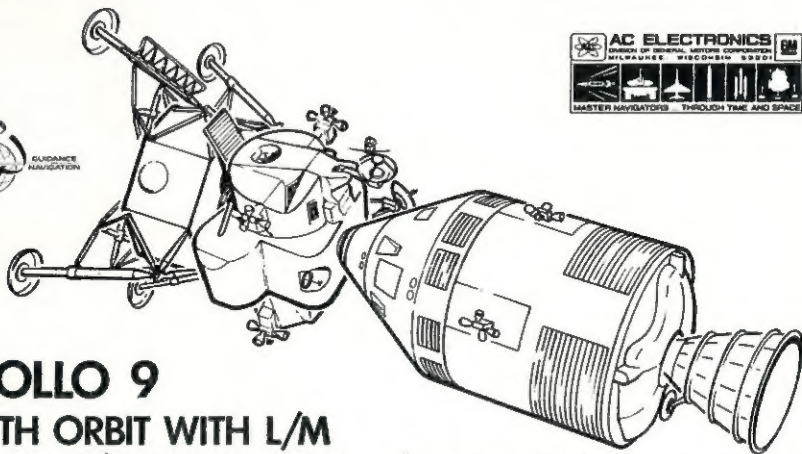


R. E. Lewis

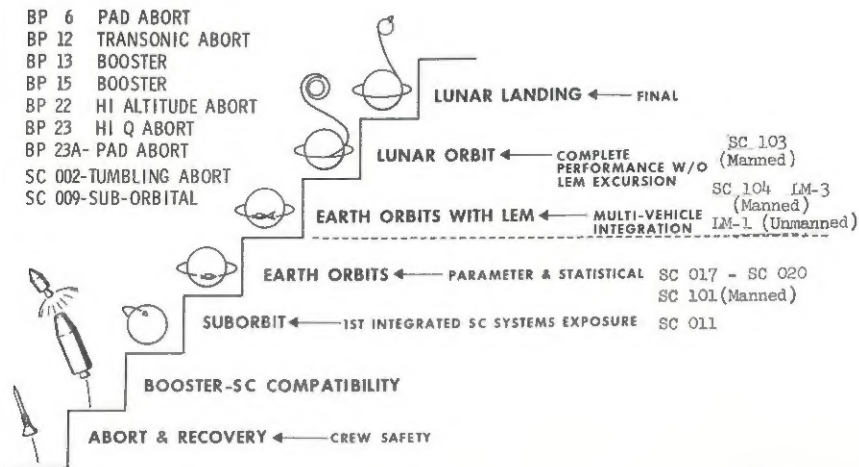


**APOLLO 9**  
**EARTH ORBIT WITH L/M**  
**AS 504 C/M 104 G&N 209 L/M 3 G&N 605**

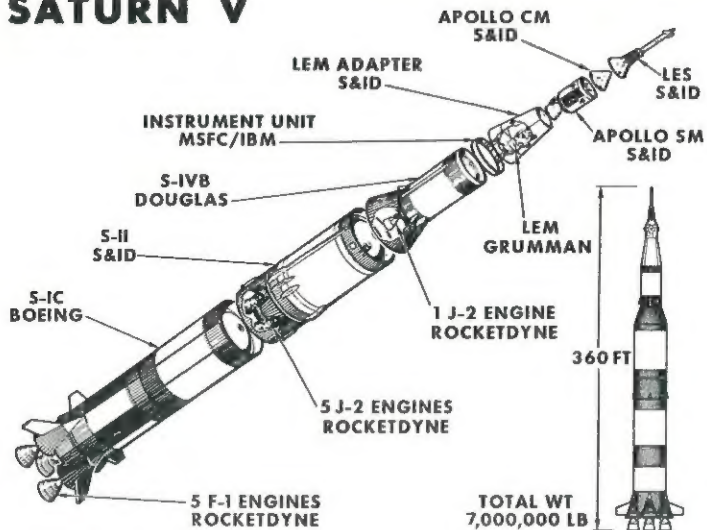


# SPACECRAFT DEVELOPMENT FLIGHT CATEGORIES

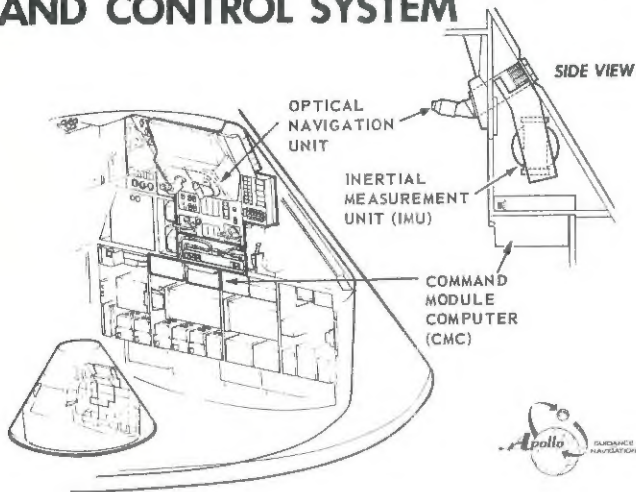
## MAJOR STEPS TO ULTIMATE MISSION



# SATURN V



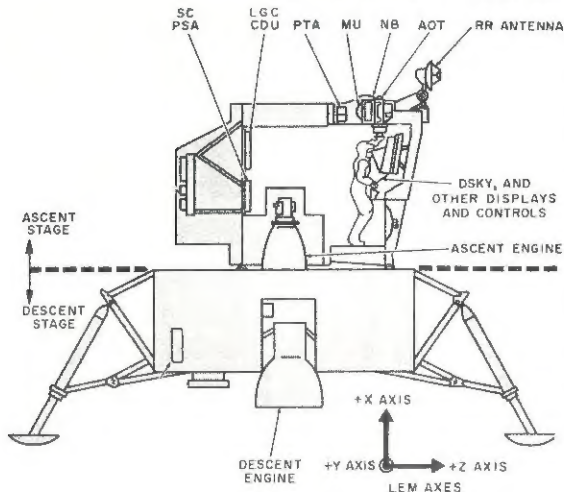
# C/M GUIDANCE, NAVIGATION, AND CONTROL SYSTEM



THE APOLLO GUIDANCE AND NAVIGATION SYSTEM IS COMPOSED OF THREE BASIC SUBSYSTEMS: INERTIAL, OPTICAL AND COMPUTER.

1. The inertial guidance subsystem is composed of inertial measurement unit (IMU) and associated equipment. This subsystem performs three major functions: (A) Measures changes in spacecraft attitude; (B) Measures spacecraft velocity due to thrust; and (C) Assists in generating steering signals.
2. The optical navigation subsystem is composed of a space sextant and a scanning telescope. Sightings on celestial bodies and landmarks on the moon and earth are used by the computer subsystem to determine the spacecraft's position and velocity and to align the inertial reference within the IMU.
3. The command module computer (CMC) provides five major functions: (A) Calculates steering signals and engine disretes necessary to keep the spacecraft on the required trajectory; (B) Positions the stable member in the IMU to a coordinate system defined by precise optical measurements; (C) Positions the optical unit to celestial objects; (D) Conducts limited malfunction isolation of the G&N system by monitoring the level and rate of system signals; and (E) Supplies pertinent spacecraft condition information to the display and control panel.

# L/M GUIDANCE AND NAVIGATION EQUIPMENT LOCATION AND DESCRIPTION



**INERTIAL MEASUREMENT UNIT (IMU)** and associated equipment performs three major functions: (A) Measures changes in LM attitude, (B) Assists in generating steering commands, and (C) Measures LM velocity changes due to thrust. This unit manufactured by AC Electronics.

**ALIGNMENT OPTICAL TELESCOPE (AOT)** Provides star sighting data which is manually inserted into the LM Guidance Computer for establishing the inertial reference. This unit manufactured by Kollsman Instrument Company.

**NAVIGATION BASE (NAV BASE)** - Provides an accurate mounting base for the Alignment Optical Telescope (AOT) and the Inertial Measurement Unit. This unit manufactured by AC Electronics.

**LM GUIDANCE COMPUTER (LGC)** Performs four major functions: (A) Calculates steering signals and engine discharges necessary to keep the LM on the required trajectory. (B) Positions the stable member in the IMU to a coordinate system defined by precise optical measurements, (C) Conducts limited malfunction isolation of the PGNCs by monitoring the level and rate of system signals, and (D) Supplies pertinent LM condition information to the display and control panels. This unit manufactured by Raytheon.

**DISPLAY AND KEYBOARD (DSKY)** Provides a two-way communication link between the operator and the LGC and the following functions may be performed: (A) Loading of data into the LGC, (B) Display of data and system configuration to the operator. This unit manufactured by Raytheon.

**COUPLING DATA UNIT (CDU)** The CDU, an all-electronic device, is used as an interface element between the following: (A) The inertial subsystem and computer subsystem, (B) and the computer subsystem and the controls. This unit functions primarily as an analog to digital or digital to analog converter. This unit manufactured by AC.

### APOLLO 9 MISSION DESCRIPTION

- |    |        |   |   |  |
|----|--------|---|---|--|
| 1. | MANNED | PRIME CREW<br>James A. McDivitt<br>David R. Scott<br>Russell L. Schweickart | COMMANDER<br>COMMAND MODULE PILOT<br>LUNAR MODULE PILOT | BACKUP CREW<br>Charles Conrad, Jr.<br>Richard F. Gordon, Jr.<br>Alan L. Bean |
|----|--------|---|---|--|
2. SECOND MANNED SATURN V MISSION
3. COMBINED CSM AND L/M EARTH ORBIT
4. PLANNED DURATION - 10 DAYS
5. BOOSTER SATURN V BOOSTER NO. 504
6. SPACECRAFT - CSM #104 AND LUNAR MODULE #3
7. BLOCK II G&N SYSTEM 209 L/M G&N SYSTEM 605

### APOLLO 9 MISSION OBJECTIVES

#### 1st PERIOD

1. CSM-ACTIVE DOCKING
2. LM EJECTION FROM THE SLA
3. CSM AUTOPILOT STABILITY MARGIN (Partial)

#### 2nd PERIOD

3. CSM AUTOPILOT STABILITY MARGIN (Completed)

#### 3rd PERIOD

4. DPS BURN DURATION EFFECTS
5. LM PGCS DAP PERFORMANCE

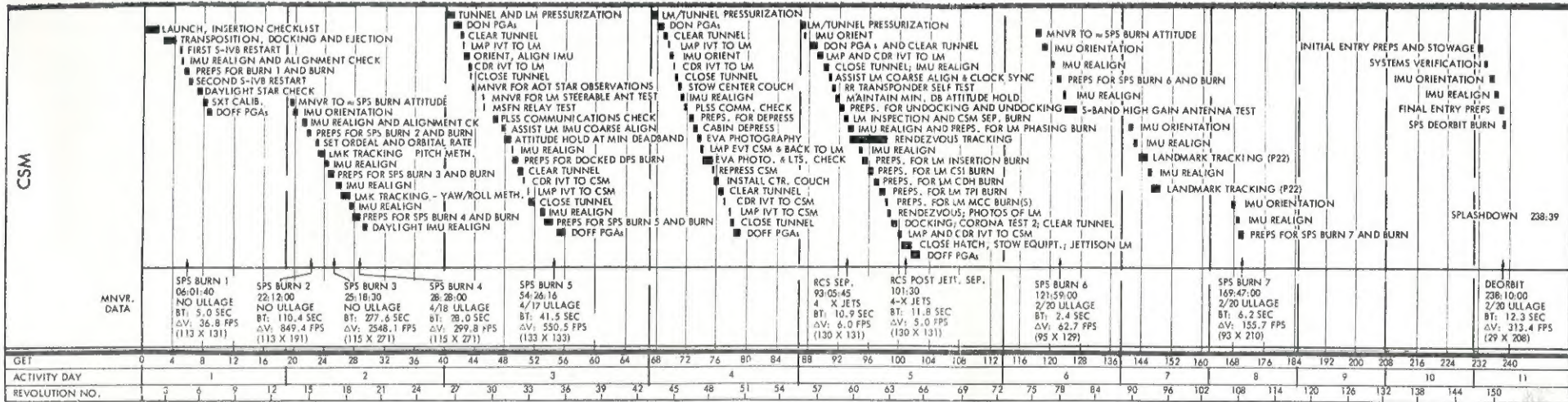
#### 4th PERIOD

6. EXTRAVEHICULAR ACTIVITY

#### 5th PERIOD

7. CSM SINGLE CREWMAN RENDEZVOUS CAPABILITY
8. AGS  $\Delta V$  CAPABILITY USING DPS
9. LM JETTISON
10. LM CSM UNDOCKING
11. PGCS CONTROLLED APS BURN
12. AGS CES ATTITUDE/TRANSLATION CONTROL
13. RENDEZVOUS RADAR TRACKING PERFORMANCE
14. LM ELEVATION RENDEZVOUS
15. LM ACTIVE DOCKING
16. APS LONG-DURATION BURN

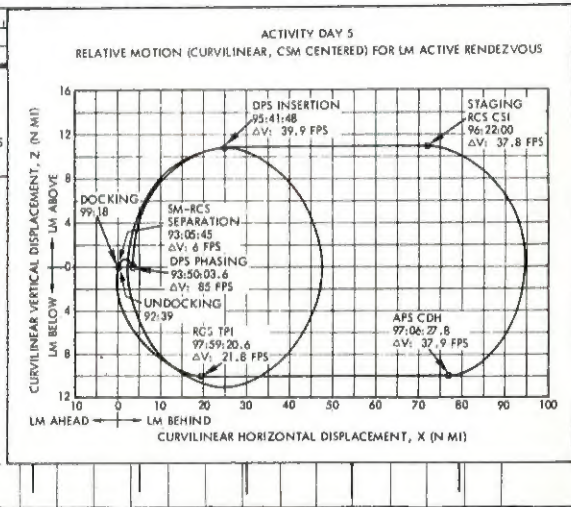
## APOLLO 9 SUMMARY FLIGHT PLAN (D MISSION)





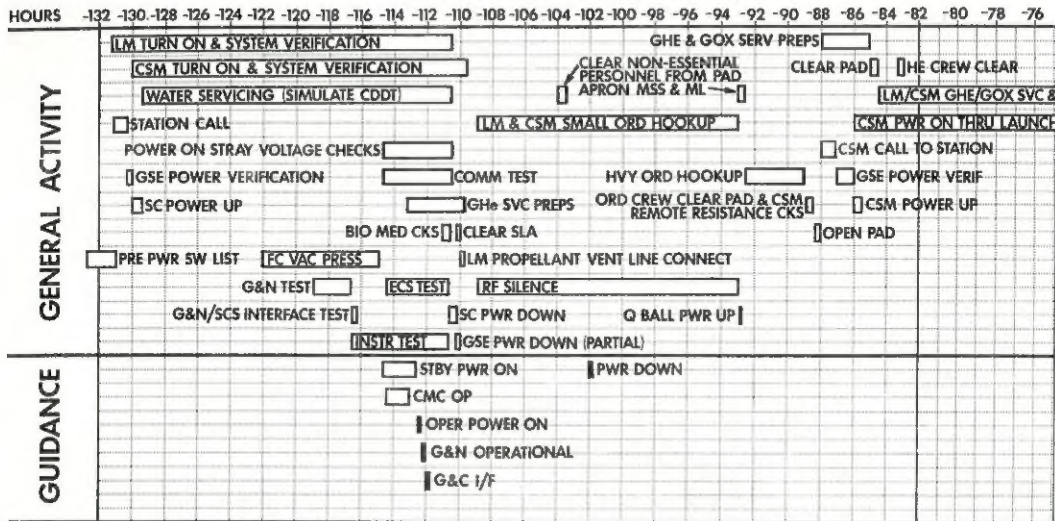
## APOLLO 9 SUMMARY FLIGHT PLAN (D MISSION)

REVOLUTION NO.		3				6				9				12				15				18				21				24				27				30				33				36				39				42				45				48				51				54				57				60				63				66				69				72				75				78			
ACTIVITY DAY		1												2												3												4												5												6																																											
GET		0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80 84 88 92 96 100 104 108 112 116 120 128																																																																																																							
LM	MNVR. DATA													DOCKED DPS 49:43:00 2/10 ULLAGE BT: 367 SEC ΔV: 1699 FPS (115 X 270)												DPS PHASING 93:50:03.6 2/8 ULLAGE BT: 25.2 SEC ΔV: 85.0 FPS (118 X 144)												DPS INSERTION 95:41:48 2/9 ULLAGE BT: 24.8 SEC ΔV: 39.9 SEC												CSI RCS 4 JET INTCON 96:22:00 BT: 30.6 SEC ΔV: 37.8 FPS (120 X 139)												CDH APS 97:06:27.8 4/4 ULLAGE BT: 3.1 SEC ΔV: 37.9 FPS (118 X 120)												TPI RCS 4 JET INTCON 97:59:20.6 BT: 17.6 SEC ΔV: 21.8 FPS (119 X 32)												APS DEPLETION 101:55 4/4 ULLAGE BT: 360 SEC ΔV: 5247 FPS (131 X 3258)																			
														■ LMP IVT TO LM ■ ENTRY CHECKS, EPS, ECS CHECKOUT ■ CDR IVT TO LM ■ CLOSE TUNNEL ■ GLYCOL, PGA, REGULATOR CHECK ■ DAYLIGHT AOT STAR VISIBILITY CHECK ■ COMMUNICATIONS TESTS & T.V. ■ S-BAND STEERABLE ANTENNA TESTS ■ MSFN RELAY TEST ■ DEPLOY LANDING GEAR ■ REMOVE AND REPLACE CARTRIDGE ■ PLSS COMMUNICATIONS CHECK ■ PGNCs, AGS, LGC ACTIVATION ■ IMU COARSE ALIGN ■ RCS PRESS, COLD FIRE HOT FIRE ■ FINE ALIGN TORQUING ■ LR, RR SELF TEST; AGS CALIBRATION ■ DPS PRESSURIZATION ■ FINE ALIGN TORQUING ■ UPDATE, ALIGN, CALIB, AGS ■ PREPS FOR DPS BURN AND BURN ■ AGS CALIB. AND LR SELF TEST ■ CDR IVT TO CSM ■ SUBLIMATOR DRY-OUT ■ LMP IVT TO CSM												■ LMP IVT TO LM ■ INITIAL LM ACTIVATION ■ CDR IVT TO LM ■ ASSIST CLOSING TUNNEL ■ COMPLETE ACTIVATION FOR EVA ■ ASSEMBLE EMU FOR EVA ■ PLSS COMM. CHECK ■ PREPS. FOR DEPRESS AND DEPRESS ■ LMP EVT TO CSM ■ RETRIEVE CSM SAMPLES ■ LMP EVT TO LM ■ RETRIEVE LM SAMPLES ■ LMP EVALUATE LIGHTING ■ H-BLAD PHOTOS AND T.V. ■ LMP INGRESS LM ■ REPRESS LM ■ PLSS RECHARGE AND DOFFING ■ REMOVE, REPLACE LIQH CART. ■ CABIN CLEANUP & STOWAGE ■ CDR IVT TO CSM ■ SUBLIMATOR DRY-OUT ■ LMP IVT TO CSM												■ LMP IVT TO LM ■ INITIAL LM ACTIVATION ■ CDR IVT TO LM ■ ASSIST CLOSING TUNNEL ■ LM ACTIVATION AND CHECKOUT ■ IMU COARSE ALIGN ■ IMU FINE ALIGN AND PREPS. FOR UNDOCKING ■ UNDOCKING AND INSPECTION MANEUVERS ■ RENDEZVOUS NAVIGATION ■ IMU REALIGN AND COAS CALIBRATION ■ PREPS. FOR PHASING AND BURN ■ IMU REALIGN ■ PREPS. FOR INSERTION AND BURN ■ PREPS. FOR CSI; STAGING AND BURN ■ PREPS. FOR CDH AND BURN ■ PREPS. FOR TPI AND BURN ■ MCC1 AND 2, BRAKING ■ RDZ., CSM PHOTO, CORONA TEST 1 ■ DOCK., CORONA TEST 2, CLEAR TUNNEL ■ CDR AND LMP IVT TO CSM ■ LM JETTISON ■ APS BURN TO DEPLETION																																																																			

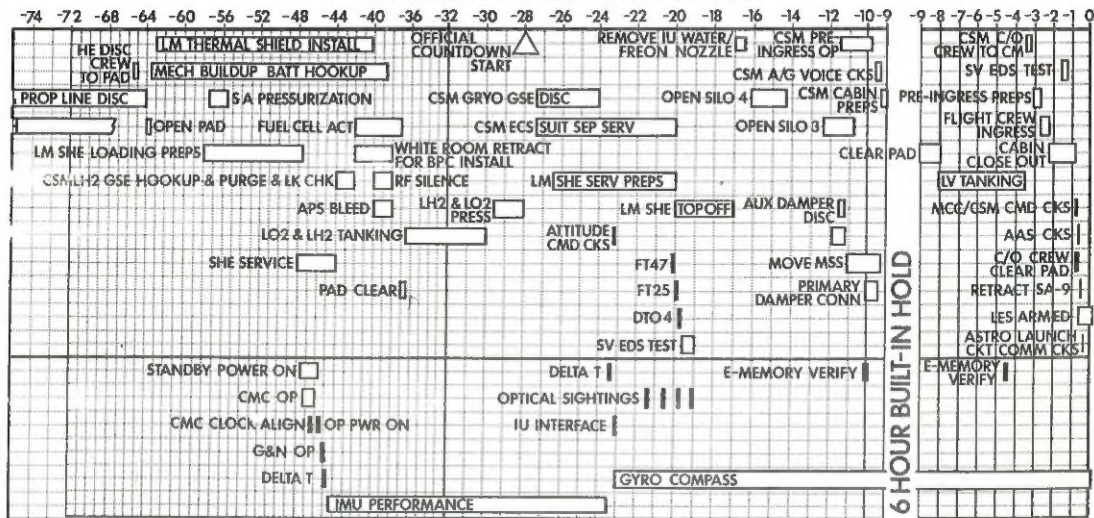




# LAUNCH COUNTDOWN SC 104



# LAUNCH COUNTDOWN SC 104



APOLLO 9 MISSION EVENTS (CSM)

C. E. T.	EVENT	G. E. T.	EVENT	G. E. T.	EVENT	
	Launch 11:00 A. M. EST	07:43	PIPA Bias Check	28:28	SPS Burn 4 BT 28.0 sec	212 P20
	10:00 A. M. CST	08:00	SXT Calib. P23		$\Delta V$ 299.8 FPS	
		08:52	Deorbit	29:22	P52, REFS	
00 11:21	Orbit Insertion	08:55	Pwr. down IMU, CMC (P06) & SCS	29:50	Update State Vector	
00:27	GDC Align to IMU			29:55	Pwr. down IMU, CMC (P06) & SCS	
00:40	Install Optics (Eyepieces)	19:00	Pwr. up IMU, CMC & SCS			
00:50	Jettison Optics Covers	19:55	P01	40:50	Pwr. up IMU, CMC, & SCS	
00:55	P52 IMU Realign REFS	20:38	Update State Vector	41:05	State Vector Update	
01:13	PIPA Check (Optional)	20:45	PIPA Bias Check	41:58	Update LM AOT Observation	
01:32	SCS Check	21:05	P30, P40		Pad, LM S-BD Steerable Pad	
02:34	SIVB Maneuver to T&D ATT	21:15	P52	42:15	LMP IVT to LM	
02:36	GDC Align	21:35	P40	42:33	Transfer LM to LM Power, P51	
02:46	P47 Thrust Monitor (Separation)	21:42	SXT Star Check	42:50	P52 PREF	
03:00	Terminate P47	22:12	SPS Burn 2 BT 110.4 sec	43:02	CDR IVT to LM	
03:03	Dock		$\Delta V$ 849.4 FPS	43:40	Mnvr. for LMAOT Star Observation	
03:16	Update State Vector	22:55	Update for Landmark Tracking	44:05	PIPA Bias Check	
03:25	Configure for Ejection			46:29	Support LM Comm. Checks as Required	
04:05	P47 Thrust Monitor	23:15	Update State Vector			
04:07	Ejection	23:40	P22 Landmark Tracking			
04:14	Terminate P47	23:55	Update State Vector	47:22	LGC/CMC Clock Sync	
04:35	SIVB Maneuver to R=0, P=0, Y=0	24:05	P30, P40	47:28	LM IMU Coarse Align	
		24:17	P52 IMU Align PREF	48:05	Update LM State Vector, CSM State Vector	100
04:36	PIPA Bias Check	24:37	P40			
04:45	1st SIVB Restart	24:40	SXT Star Check	48:40	P52-REFS	
04:52	MCC Update State Vector	25:18:30	SPS Burn 3 BT 277.6 sec	49:08	P30, P40 SPS Thrust	1100
04:58	P30 External $\Delta V$	25:35	$\Delta V$ 2548.1 FPS	49:25	P41 RCS Thrust	
			Computer Update Desired Orient for Ldmk. Track	49:43	Docked DPS Burn	11 43
05:10	P40 SPS Thrust				BT 367 Sec $\Delta V$ -1699 FPS	10,11,12 750
05:26	P52 IMU Align PREF	25:47	P52 IMU Align PREF	49:50	P76	
05:28	P40 SPS Thrust	26:10	Computer Update Ldmk. Track	50:15	CDR IVT to CSM	
05:28	SXT Star Check	26:40	Update State Vector	51:12	LMP IVT to CSM	
06:01	SPS Burn 1 BT 5.0 sec	26:50	P22 Ldmk. Tracking	52:53	Update State Vector	
	$\Delta V$ 36.8 FPS	27:05	Update State Vector	53:05	P30, P40	
06:06	2nd SIVB Restart	27:15	P30, P40	53:12	P52-PREF	
06:15	Update for Daylight Star Check	27:22	P52-PREF	53:30	P40	
07:00	Daylight Star Check	27:45	P40	53:35	SXT Star Check	
07:23	Update State Vector & desired IMU orient for Deorbit	27:50	SXT Star Check	54:26	SPS Burn 5 BT 41.5 sec	
					$\Delta V$ 550.5 FPS	

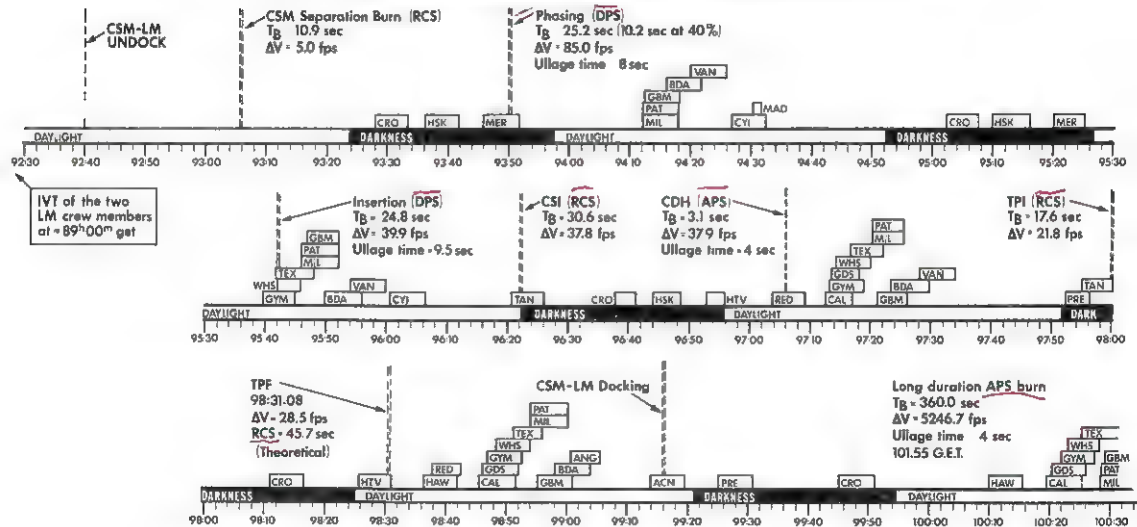
# APOLLO 9 MISSION EVENTS (CSM)

G. E. T.	EVENT	G. E. T.	EVENT	G. E. T.	EVENT
55:37	Update State Vector	94:55	P52-REFS	140:45	P51
55:57	Pwr. down IMU, CMC (P06) & SCS	95:30	P30, P40	141:35	Update State Vector, Nom Orient
67:35	Flight Plan Update	95:43	P76, P20	141:40	PIPA Bias Check
68:00	Pwr. up IMU, CMC & SCS	96:03	V85, V83, P30	142:16	P52-Nom
69:23	LMP IVT to LM	96:10	P40-SPS Thrust	142:33	Update-Landmark Tracking
69:35	P51	96:24	P76, P20	143:05	P22
69:55	Update State Vector & Desired Orientation	96:40	P17 IPI Search	143:14	Update Landmark Tracking
70:08	CDR IVT to LM	96:57	P30, P40	144:45	P22
71:05	P52-PREF	97:10	P76, P20	145:22	P52-REFS
71:53	PIPA Bias Check	97:20	P34 IPI	145:43	P22
76:46	CDR IVT to CSM	97:53	P40	148:50	Update State Vector
77:37	LMP IVT to CSM	98:00	P76	149:00	Pwr. down IMU, CMC & SCS
77:45	Update State Vector	98:27	P47 Thrust Monitor	166:10	Pwr. up IMU, CMC & SCS
78:00	Pwr. down IMU, CMC (P06) & SCS	98:35	Rendezvous	167:17	P51
87:05	Pwr. up IMU, CMC & SCS	99:17	Docking	168:10	Update State Vector
87:26	P51	100:00	CDR IVT to CSM	168:15	PIPA Bias Check
89:05	Update CSM State Vector	100:21	LMP IVT to CSM	168:30	P30, P40
	LM State Vector, Desired Orientation	101:25	LM Jettison	168:45	P52-PREF
89:14	LMP IVT to LM	101:30	Post Jettison SEP Mnvr	169:00	Load DAP, P40 SPS Thrust
89:25	Transfer LM to LM Power	103:07	BT 11.8 sec $\Delta V$ 5.0 FPS	169:07	SXT Star Check
89:55	CDR IVT to LM	103:15	Update State Vector	169:47	SPS Burn 7 BT 6.2 sec
90:25	P52-PREF		Pwr. down IMU, CMC (P06) & SCS		$\Delta V$ 155.7 FPS
90:37	LM/CMC Clock Sync.	117:45	Pwr. up IMU, CMC & SCS	170:38	Update State Vector
91:07	CMC Free Mode	118:40	P51	170:48	Pwr. down IMU, CMC, & SCS
91:56	PIPA Bias Check	119:25	PIPA Bias Check	232:50	Pwr. up IMU, CMC & SCS
92:39	CSM/LM Undocking	119:40	Update State Vector	233:47	PIPA Bias Check
93:00	P30, P41 RCS Thrust	119:50	P30, P40	234:37	P51
93:05	SM RCS SEP Burn BT 10.9 sec $\Delta V$ 5.0 FPS	120:07	P52-PREF	235:15	Update State Vector, Tgt. Load, Desired IMU Orient, Mnvr. Pad, Entry Pad
93:10	P20 Rndz. Nav.	121:20	P40 SPS Thrust	236:07	P-2 PRIF
93:25	P52-REFS	121:40	SXT Star Check	236:32	EXT $\Delta V$ P30
93:37	V85, P30, P40	121:59	SPS Burn 6	237:18	Load DAP, P40 SPS Thrust
93:53	P76, P20	123:06	BT 2.4 sec $\Delta V$ 62.7 FPS	237:42	SXT Star Check
94:05	P34, V32	125:20	P52-Nom	238:10	SPS Deorbit Burn BT 12.3 sec
			Update State Vector, HI-Gain Antenna Pointing		$\Delta V$ 313.4 FPS
		125:55	Pwr. down IMU, CMC & SCS	238:15	CM/SM Separation
		139:55	Pwr. up IMU, CMC & SCS	238:25	EI 400K
				238:35	Chutes Deployed
				238:39	SPLASH DOWN

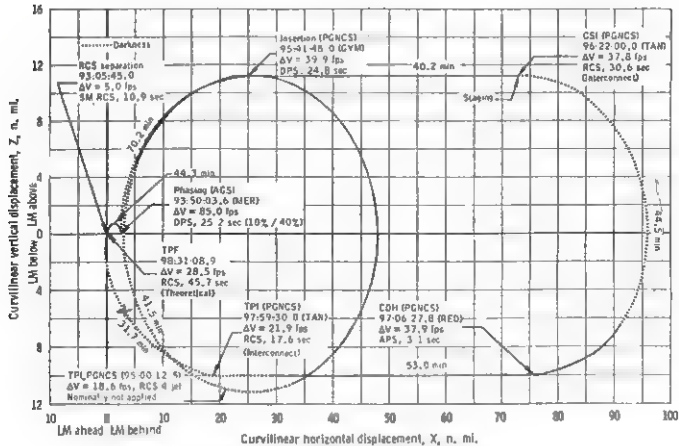
# APOLLO 9 MISSION EVENTS (LM)

G. E. T.	EVENT	G. E. T.	EVENT	G. E. T.	EVENT
42:15	LM IVT to LM	59:55	LM IVT to LM	96:22	CSI Staging Burn BT 30.6 sec
42:33	Transfer to LM Power	76:46	CDR IVT to CSM	96:27	$\Delta V$ 37.8 FPS
42:50	ECS Activation & Checkout	77:28	Transfer to CSM Power	96:40	P20
43:02	CDR IVT to LM	77:38	LMP IVT to CSM	97:00	P30
43:50	Ascent Batt ACT & Checkout	89:14	LMP IVT to LM	97:06	P42
43:57	Daylight AOT Star Check	89:55	CDR IVT to LM	97:10	APS-CDH Burn BT 3.1 sec
	Visibility	90:30	PGNCS Turnon & Self-Test	97:10	$\Delta V$ 37.9 FPS
44:07	Comm. Checks	90:37	LGC Check Initialization &	97:55	P20
44:50	S-Band Steerable Ant. Check		Tephem Check	97:59	P41
46:29	LM Pass to 46:34	90:43	IMU Coarse Align	98:10	RCS-TP1 Burn BT 17.6 sec
46:46	Comm Checks	91:08	E Memory Dumps (2)	98:22	$\Delta V$ 21.8 FPS
47:22	PGNCS Turnon & Self-Check	91:10	Update LM State	98:22	P41 RCS Thrust-MCC <sub>1</sub>
	LGC Clock Initialization		Vector, CSM State	98:35	P41 RCS Thrust-MCC <sub>2</sub>
	Load Tephem, E-Mem Dump		Vector, REFS	99:17	Rendezvous
47:28	IMU Docked, Coarse Align	91:38	IMU Fine Align and PIPA	99:45	Docking
47:42	PIPA Bias Check		Bias Check	99:53	Update LM State Vector
48:13	Update LM State Vector	92:49	CSM/LM Undocking	100:00	P30, PIPA Bias Check
	Gyro Torquing Angles	93:21	P30	100:15	CDR IVT to CSM
48:15	IMU Fine Align Torquing	93:23	P52 REFS Option	100:21	P42, Enter P00
49:05	Update Gyro Torquing	93:45	P40 DPS Thrust	100:45	LMP IVT to CSM
	Angles, Fine Align Torquing	93:50	Phasing Burn BT 25.2 sec	101:15	LM Jettison
49:25	P30 P40 DPS Thrust		$\Delta V$ 85.0 FPS	101:55	MCC CMD Enter P42 APS Thrust
49:41	Docked DPS Burn BT 367 sec	93:55	P20		MCC CMD APS Burn to
	$\Delta V$ 1699 FPS	94:05	P34		Depletion BT 360.0 sec
50:15	CDR IVT to CSM	94:20	Update P20		$\Delta V$ 5247 FPS, Orbit 3258 x 131
50:30	Initial Power Down	94:30	V93, V32 at 4 Marks		
51:05	Transfer to CSM Power	94:55	P52 REFS Option		
51:12	LMP IVT to CSM	95:07	P20		
59:23	LMP IVT to LM	95:08	P40-OPS Thrust		
59:38	Transfer to LM Power	95:41	Insertion Burn BT 24.8 sec		
70:48	EVA Preparation		$\Delta V$ 39.9 FPS		
73:13	LMP Egress LM	95:47	L2		
73:28	LMP EVT to CM (Ingress CM)	96:00	P32		
73:45	LMP EVT to LM (Egress CM)	96:16	P41 RCS Thrust		
	Ingress LM)				

# CSM-LM RENDEZVOUS PERIOD 92:30 hours to 100:30 hours







Relative motion (curvilinear, CSM-centered) for LM-active rendezvous of mission D.

SEQUENCE OF EVENTS FOR SPACECRAFT MANEUVERS

Period of Activity	Event	G. e. t. of initiation hr min:sec	Time to next event, hr min:sec	Propulsion system	Burn Time sec	Ullage Time sec	Total $\Delta V$ fps	Guidance Mode	Resulting $h_p/h_p$ n. mi	Tracking Stations
1	Launch <sup>a</sup>	00:00:00.0	00:21:35.3		--	--			--	ETR
	Insertion	00:11:35.3	02:22:24.7							ETR, VAN
	S-IVB to separation attitude	02:34:00.0	00:09:00.0	APS						None
	CSM separation & docking <sup>b</sup>	02:43:00.0	01:25:57.0	SM RCS	7.0		1.0			
	LM ejection	04:08:57.0	01:52:43.0	SM RCS	3.0		0.4		112/109	None
	SPS-1 (docked)	06:01:40.0	16:10:20.0	SPS	5.0	0	36.8	G&N ext $\Delta V$	131/113	HAW
2	SPS-2 (docked)	22:12:00.0	03:06:30.0	SPS	110.4	0	849.4	G&N ext $\Delta V$	191/113	BDA
	SPS-3 (docked)	25:18:30.0	03:09:30.0	SPS	277.6	0	2548.1	G&N ext $\Delta V$	271/115	MIL, BDA
	SPS-4 (docked)	28:28:00.0	14:32:00.0	SPS	28.0	20	294.8	G&N ext $\Delta V$	271/115	TEX
3	LM systems evaluation	40:00:00.0	09:43:00.0							
	DPS burn (docked)	49:43:00.0	04:43:16.0	DPS	364.0	10	1698.3	PGNCS - ext $\Delta V$	270/115	MIL, BDA
	SPS-5 (docked)	54:26:16.0	17:13:44.0	SPS	61.5	20	550.5	G&N ext $\Delta V$	133/133	GYM
	EVA	71:40:00.0	21:25:45.0							
5	CSM separation burn	93:05:45.0	00:44:18.0	SM RCS	10.9		5.0		131/130	None
	Phasing	93:50:03.6	01:51:44.4	DPS <sup>d</sup>	25.2	57	85.0	AGS ext $\Delta V$	144/116	MER
	Insertion	95:41:48.0	00:40:12.0	DPS 10%	24.8	57	39.9	PGNCS - ext $\Delta V$	143/141	GYM
	CSI	96:22:00.0	00:44:27.8	LM RCS	30.6	0	37.8	PGNCS - ext $\Delta V$	139/120	TAN
	LDH	97:06:27.8	00:52:52.8	APS	1.1		17.9	PGNCS - ext $\Delta V$	120/118	RED
	FPI	97:59:20.6	02:26:39.4	LM RCS	17.6	0	21.9	PGNCS - Lambert	132/119	TAN
	APS long duration burn	100:26:00.0	21:33:00.0	APS	340.0	3	5240.4	PGNCS - ext $\Delta V$	323/129	GYM, TEX, MIL
6	SPS-6 (solo)	121:59:00.0	47:48:00.0	SPS	2.4	20	62.7	G&N ext $\Delta V$	129/95	CRO
	SPS-7 (solo)	169:47:00.0	68:25:00.0	SPS	6.2	20	155.7	G&N ext $\Delta V$	210/93	MIL
	SPS-8 (doorbu)	238:10:00.0	00:15:30.4	SPS	12.3	20	313.4	G&N ext $\Delta V$	208/29	HAW, RED

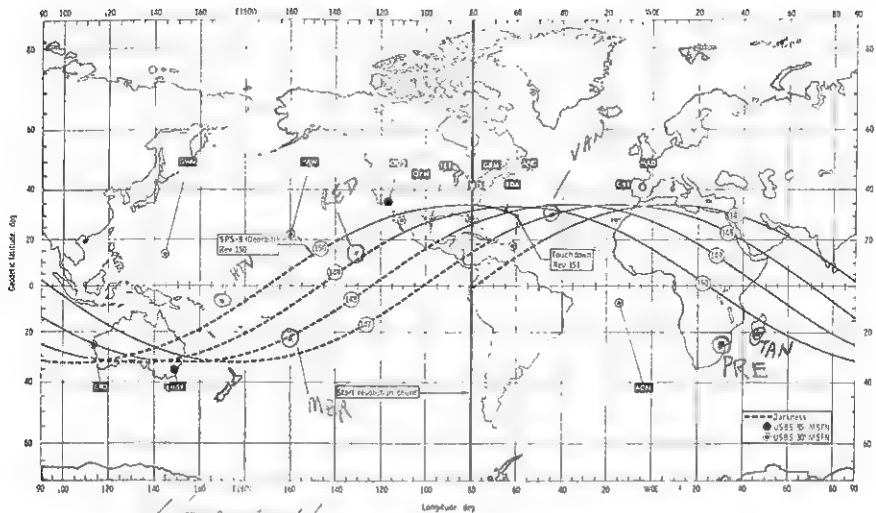
<sup>a</sup>Launch is assumed to occur at 1100 Hrs. EST on February 28, 1969.

<sup>b</sup>Ullage time given is for separation from S-IVB with 50% jet.

<sup>c</sup>7 jet ullage.

<sup>d</sup>10 percent thrust for 15 seconds; 40 percent thrust for 10, 2 seconds.

<sup>e</sup>The velocity-to-be-gained residuals will be trimmed by RCS using PGNCS (if necessary).



Handwritten note: *1st Revolution 142 to Touchdown*

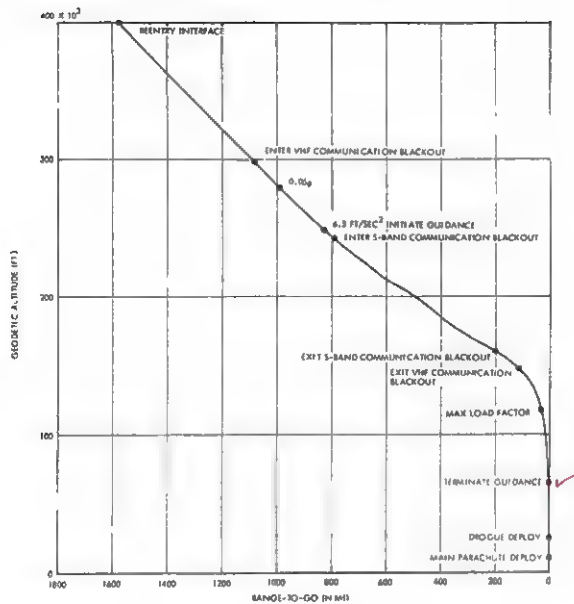
1st Revolution 142 to Touchdown

Handwritten note: *HTV - 400 lbs*  
*MER - increasing*

# CM SEQUENCE OF EVENTS FOR REENTRY

	Time from lift-off, hr min sec	Entry time, min sec	Geodetic latitude, deg	Longitude, deg	Altitude, ft	Inertial velocity, fps	Inertial flight-path angle, deg	Range to target, n. mi.
Entry interface	238 25 30 38	0	33 36	-89 70	400 000	25 798	-1.88	1572
0.05g	238 27 52 38	2 22	33 36	-78 46	282 538	25 905	-1.76	1007
Start Kepler phase	238 27 54 38	2.24	33 35	-78 30	280 935	25 904	-1.76	999
Entry final phase	238 28 30 38	3 00	33 17	-75 45	252 800	25 788	-1.65	855
Peak entry load factor	238 33 30 37	8 00	30 75	-59 48	109 794	6 140	7.33	27
Guidance termination	238 34 40 37	<u>8.10</u>	30 62	-59 00	<u>59 684</u>	<sup>a</sup> 1 002	<sup>a</sup> 52.01	0.73
Drogue parachute deployment	238 35 38 89	10 08	30 64	-58 97	23 491	<sup>a</sup> 467	<sup>a</sup> -74.11	-1.26
Main parachute deployment	238 36 24 82	10 55	30 64	-58 97	10 200	<sup>a</sup> 234	<sup>a</sup> 89.0	-1.33
Touchdown	238 40 47 61	15 18	30 64	-58 97	9	<sup>a</sup> 30	<sup>a</sup> -89.8	-1.46

<sup>a</sup>Relative velocity and flight-path angle.



Altitude and range profile for reentry.

# C/M COMPUTER PROGRAMS

PHASE	PROGRAM NUMBER	PROGRAM TITLE
PRE-LAUNCH AND SERVICE	00	CMC IDLING
	01	PRELAUNCH OR SERVICE-INITIALIZATION
	02	PRELAUNCH OR SERVICE GYRO COMPASSING
	03	PRELAUNCH OR SERVICE OPTICAL VERIFICATION OF GYRO COMPASSING
	06	GNCS POWER DOWN
	07	<u>SYSTEMS TEST</u>
BOOST	11	EARTH ORBIT INSERTION MONITOR (EOI)
	17	TRANSFER PHASE INITIALIZATION SEARCH (TPI)
COAST	20	RENDEZVOUS NAVIGATION
	21	GROUND TRACK DETERMINATION
	22	ORBITAL NAVIGATION
	23	CISLUNAR MIDCOURSE NAVIGATION
	27	CMC UPDATE
PRE- THRUSTING	30	EXTERNAL DELTA V
	31	LAMBERT AIMPOINT MANEUVER
	34	TRANSFER PHASE INITIATION (TPI)
	35	TRANSFER PHASE (MIDCOURSE)
	37	RETURN TO EARTH (RTE)
	38	STABLE ORBIT RENDEZVOUS (SOR)
	39	STABLE ORBIT MIDCOURSE (SOM)
THRUSTING	40	SPS
	41	RCS
	47	THRUST MONITOR
ALIGNMENT	51	IMU ORIENTATION DETERMINATION
	52	IMU REALIGN
	53	BACK-UP IMU ORIENTATION DETERMINATION
	54	BACK UP IMU REALIGN
ENTRY	61	ENTRY-MANEUVER TO CM/SM SEPARATION ATTITUDE
	62	ENTRY-CM/SM SEPARATION AND PRE-ENTRY MANEUVER
	63	ENTRY INITIALIZATION
	64	ENTRY-POST 0.05G
	65	ENTRY-UP CONTROL
	66	ENTRY-BALLETIC
	67	ENTRY-FINAL PHASE
ABORT	74	LM TRANSFER PHASE INITIATION (TPI) TARGETING
	75	LM TRANSFER PHASE (MIDCOURSE) TARGETING
	76	LM TARGET DELTA V
	77	LM TPI SEARCH
	78	LM SOR TARGETING
	79	LM SOM TARGETING



## (LM EARTH ORBITAL)

## COMPUTER PROGRAMS

PHASE	PROGRAM NUMBER	PROGRAM TITLE
SERVICE	00	CMC IDLING
	06	LGC POWER DOWN
ASCENT	10	PREDICTED LAUNCH TIME (CFP)
	11	PREDICTED LAUNCH TIME (DT)
	12	POWERED ASCENT
COAST	20	RENDEZVOUS NAVIGATION
	21	GROUND TRACK DETERMINATION
	22	LUNAR SURFACE NAVIGATION
	25	PREFERRED TRACKING ATTITUDE
	27	LGC UPDATE
PRE- THRUSTING	30	EXTERNAL DELTA V
	31	LAMBERT AIM POINT GUIDANCE
	32	CO-ELLIPTIC SEQUENCE INITIATION (CSI)
	33	CONSTANT DELTA ALTITUDE (CDH)
	34	TRANSFER PHASE INITIATION (TP)
	35	TRANSFER PHASE MIDCOURSE (TPM)
	38	STABLE ORBIT RENDEZVOUS (SOR)
	39	STABLE ORBIT MIDCOURSE (SOM)
THRUSTING	40	DPS
	41	RCS
	42	APS
	46	LM/CSM SEPARATION MONITOR
	47	THRUST MONITOR
ALIGNMENT	51	IMU ORIENTATION DETERMINATION
	52	IMU REALIGN
	57	LUNAR SURFACE ALIGN
DESCENT	63	BRAKING PHASE
	64	APPROACH PHASE
	65	LANDING PHASE (AUTO)
	66	LANDING PHASE (ROD)
	67	LANDING PHASE (MANUAL)
ABORTS AND BACKUPS	70	DPS ABORT
	71	APS ABORT
	72	CSM CO-ELLIPTIC SEQUENCE INITIATION (CSI) TARGETING
	73	CSM CONSTANT DELTA ALTITUDE (CDH) TARGETING
	74	CSM TRANSFER PHASE INITIATION (TP) TARGETING
	75	CSM TRANSFER PHASE MIDCOURSE (TPM) TARGETING
	78	CSM STABLE ORBIT RENDEZVOUS (SOR) TARGETING
	79	CSM STABLE ORBIT MIDCOURSE (SOM) TARGETING

OPTION CODES (V04N06)				
RI CODE	PURPOSE	R2 CODE		
00001	IMU ORIENTATION	1 = PREF	2 = NOM	3 = REF
00002	VEH CLE	1 = THIS	2 = OTHER	
00003	TRACK ATTITUDE	1 = PREF	2 = +X AXIS	
00005	SOR PHASE	1 = FIRST	2 = SECOND	
00007	PROP SYSTEM	1 = SPS	2 = RCS	

CHECKLIST REF CODES (V50N25)	
RI CODE	ACTION
00014	PERFORM FINE ALIGN
00015	ACQUIRE CELESTIAL BODY
00016	TERMINATE MARKS
00041	CM SM SEP
00062	KEY CMC TO STBY
00202	G&N AUTO MNVR
00203	SWITCH TO CMC-AUTO
00204	SPS GMBL TRIM

ALARM CODES (V05N09)		
CODE	DESCRIPTION	CORRECTIVE ACTION
00110	MARK REJECT UNNECESSARY	RSET CONT
00112	MARK NOT ACCEPTED	RSET CONT
00113	NO INBITS	RSET REATTEMPT ENTRY
00114	MARK NOT DESIRED	RSET CONT
00115	TOR REQ - OSS NOT IN CMC	SET OSS TO CMC RSET CONT
00116	OSS SW BEFORE 15 SEC	SET OSS TO ZERO RSET CONT
00117	TOR REQ OSS NOT AVAIL	RSET

00120	TOR REQ OSS NOT ZEROED	SET OSS TO ZERO RSET CONT
00121	CDUS NO GO AT MARK	RSET REPEAT MARK
00122	MARKING NOT CALLED FOR	RSET
00124	NO SOLUTION TO TPI	RSET V32E
00205	PIPA SATURATED	SWITCH TO SCS
00206	ZERO ENCODE NOT ALLOWED	RSET V41 V40
00211	COARSE ALIGN ERROR	ERROR KEY V06N20E
00215	PREF ORIENT NOT SPECIFIED	RSET DEFINE PREF
00217	ISS MODE SWITCH FAIL	RSET REINITIATE PROG
00220	IMU NOT ALIGNED	RSET
00401	DESIRED ANGLES GMBL LOCK	RSET AVOID GMBL LOCK
00404 *	TARGET OUT OF 90 DEG	RSET MNVR NEW TGT
00405	TWO STARS NOT AVAIL	MNVR RSET V32
00406	P20 NOT OPERATING	RSET
00407	TARGET OUT OF 50 DEG	RSET MNVR
00421	W MATRIX OVERFLOW	RSET P27 S.V. UPDATE
00611	NO TIG FOR ELEV ANGLE	V32E NEW ELEV RSET
01105	DOWN TEL TOO FAST	RSET
01106	UP TEL TOO FAST	RSET RETRANSMIT
01207 *	NO VAC AREA FOR MARKS	RSET TERM. REINITIATE
01211 *	ILLEGAL RUPT OF EXTD VERB	RSET TERM. REINITIATE
01302	NO SOLUTION	RSET REINITIATE PROG
01407	VG INCREASING	TERMINATE THRUST RSET
01426	IMU UNSAT	RSET REALIGN IMU
01427	IMU REVERSED	RSET CONT 0 DEG = LIFT DN
01520	V37 NOT ALLOWED	RSET
01703	CANNOT INTEG SV TO TIG	RSET AUTO TIG SLIP

\* RESTART # AUTO DISPLAY

# VERB LIST

40 ZERO KDU  
41 COARSE  
42 FINE  
43 LOAD ERRORS  
46 ACTIVATE DAP  
47 LM INTO CSM  
48 LOAD DAP  
49 CREW MNVR  
54 COAS MARK  
55 ADD ΔTIME  
56 STOP TRACK  
57 SXT MARK  
58 RESET STICK  
60 SET N17=N20

61 FOLLOW ERROR  
62 FINAL ERROR  
63 N17 ERROR  
64 S BAND ANT  
66 CSM INTO LM  
67 W MATRIX RMS  
68 STROKER  
70 UPDATE LO  
71 BLOCK UPDATE  
72 SINGLE UPDATE  
73 UPDATE TIME  
74 ERASE DUMP  
76 SET PREF FLG  
77 RESET PREF

80 UPDATE LM SV  
81 UPDATE CSM SV  
82 ORBIT PARAM  
83 RLR DOT.THETA  
85 RLR DOT.PHI  
86 REJ COAS MK  
89 RNDZ ATT MNVR  
90 OUT OF PLANE  
93 INITIALIZE W  
96 TERM INTEG

## NOUN LIST

17 CRW.AT  
20 PRE.AT  
22 NEW.AT  
24 ΔTIME  
32 T FM PER  
33 TIG  
35 T FM EVT  
37 TIG TPI  
38 T ST VEC  
39 ΔT TNFR

40 TF TIG  
VGXX.X  
ΔV MX.X  
41 TGT.AZ  
TG.TEL  
IDENT  
HAXX.X  
HPXX.X  
ΔV RE.Q  
43 LAT.XX  
LON.GX  
ALT.XX  
HAXX.X  
HPXX.X  
TFF  
49 ΔR XX.X  
ΔV XX.X  
S CODE  
50 ΔR MIS  
HPXX.X  
TFF  
51 RHO.XX  
GAM.MA  
53 RANGE  
RDOT.X  
PHI.XX  
54 RANGE  
RDOT.X  
THE.TA  
55 P CODE  
ELE.VX  
CEN.AN  
56 ENANG  
ΔVXXX.  
57 ΔR SO.R

58 HPXX.X  
ΔV TP.I  
ΔV TP.F  
59 ΔV LO.S  
61 LAT.XX  
LON.GX  
72 ΔAN.GX  
ΔALT.X  
81 ΔV LV.X  
84 ΔV LM.X  
85 ΔV CO.N  
87 TR.UNN  
88 .PLANT  
89 LATXX  
LNG/2  
ALT.XX

90 YXX.XX  
YDOT.X  
PSI.XX  
91 PRS.FT  
PR.TRN  
92 NWS.FT  
NW.TRN  
93 ΔG.YRO  
94 SHAFT  
TR.UNN  
95 PRF.AT  
96 +XA.TT  
99 POS.ER  
VELE.R

# NOUN 70 CODES

R1: CELESTIAL BODY CODE 000XX R2: LANDMARK DATA ABCDE

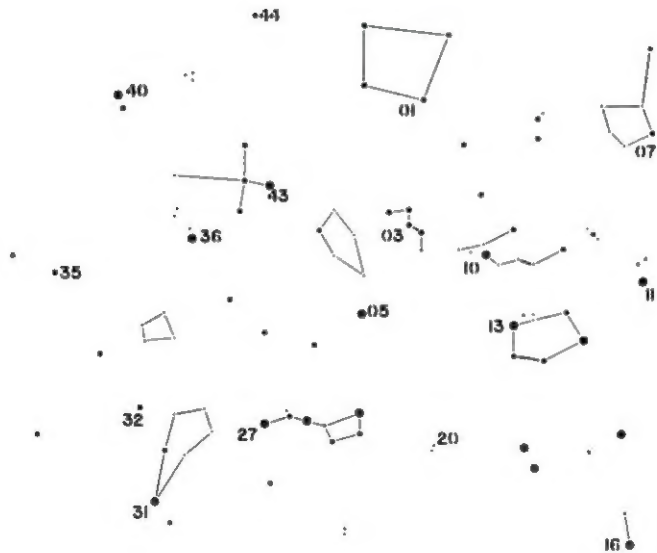
00	PLANET	27	ALKAID
01	ALPHERATZ	30	MENKENT
02	DIPHDA	31	ARCTURUS
03	NAVI	32	ALPHECCA
04	ACHERNAR	33	ANTARES
05	POLARIS	34	ATRIA
06	ACAMAR	35	RASALHAGUE
07	MENKAR	36	VEGA
10	MIRFAK	37	NUNKI
11	ALDEBARAN	40	ALTAIR
12	RIGEL		
13	CAPELLA		
14	CANOPUS		
15	SIRIUS		
16	PROCYON		
17	REGOR	41	DABIH
20	DNOCES	42	PEACOCK
21	ALPHARD	43	DENEK
22	REGULUS	44	ENIF
23	DENEbola	45	FOMALHAUT
24	GIENAH	46	SUN
25	AGRUX	47	EARTH
26	SPIGA	50	MOON

A = 1 IF KNOWN LDMK  
A = 2 IF UNKNOWN LDMK  
B = INDEX OF OFFSET DESIG  
C = NOT USED  
DE = LDMK ID NO

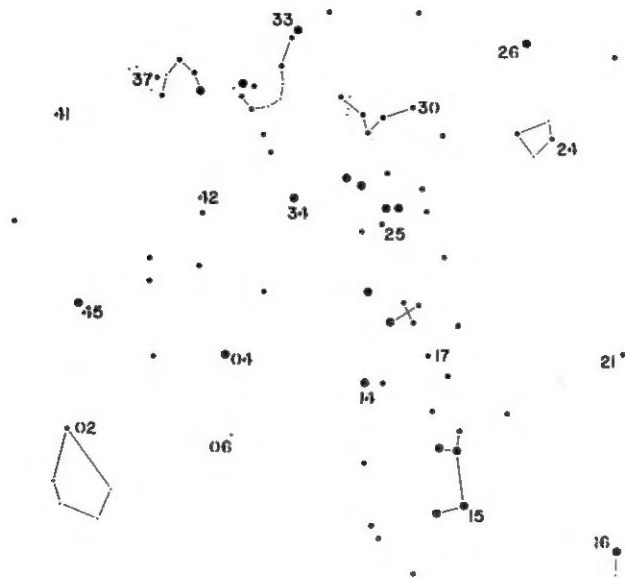
R3: HORIZON DATA 00000

C = 1 FOR EARTH HORIZON  
C = 2 FOR MOON HORIZON  
D = 1 FOR NEAR HORIZON  
D = 2 FOR FAR HORIZON

# NORTH STAR CHART



# SOUTH STAR CHART





ABBREVIATIONS

ACN	Ascension Tracking Station
AGS	abort guidance system
ANG	Antigua Tracking Station
APS	ascent propulsion system
BDA	Bermuda Tracking Station
CAL	California Tracking Station
CDH	constant differential height
CES	control electronics system
CRO	Carnarvon Tracking Station
CSI	concentric sequence initiation
CSM	command and service module
DAP	digital autopilot
DPS	descent propulsion system
EMU	extravehicular mobility unit
EVA	extravehicular activity
EVT	extravehicular transfer
FTP	fixed throttle point
GBM	Grand Bahama Tracking Station
GDS	Goldstone Tracking Station
g. e. t.	ground elapsed time
G. m. t.	Greenwich mean time
G&N	guidance and navigation
GYM	Guaymas Tracking Station

ABBREVIATIONS

HAW	Hawaii Tracking Station
IVT	Intravehicular transfer
LM	lunar module
LOS	loss of signal
MER	Mercury Tracking Ship
MIL	Merritt Island Tracking Station
MSFN	Manned Space Flight Network
PGNCS	primary guidance and navigation control subsystem
PLSS	portable life support system
PRE	Pretoria Tracking Station
RCS	reaction control subsystem
SLA	spacecraft LM adapter
SPS	service propulsion system
S-IC	Saturn IC, LV first stage
S-II	Saturn II, LV second stage
S-IVB	Saturn IVB, LV third stage
TAN	Tananaive Tracking Station
T&D	transposition and docking
TEX	Corpus Christi Tracking Station
TLI	translunar injection
TPJ	terminal phase initialization
TPF	terminal phase finalization
VAN	Vanguard Tracking Ship

30000E 2176E

SB 3000E 2176E

B4-up face closure

X-leader has 5.5 amp work.

NOR R on RR Self test - Sup prob.  
cleared up

TEP SW failed closed - 4 granges  
Photo chamber pressure

10:55 Cant initialize ABS from

RBNC5 -

IMU - LM 282.02

208.76

026.59

10:59 possible DPS to manual of leak

V47 ABS data

re plant initialization

- out of RBNC5 OK -

11:09 Unit 2 in OK -

46C K factor left out

LRTup.

81 - start

95 - 900 fps

100 - F40